

REMARKS

In the office action mailed December 10, 2002, the Examiner has objected to several instances in the specification where typographical errors occurred or where clarification was otherwise required. Applicants believe that all of these instances have been addressed through the amendments to the specification and drawings contained hereinabove.

The Examiner has also objected to several of the drawings as requiring attention. Applicants submit herewith new FIGs. 7 and 8 which illustrate a periodic "swiss roll" resonator structure and a periodic spiral resonator structure, respectively.

These drawings do not contain new matter.

→ Detail Description needed

In the office action the Examiner also objected to the specification as failing to provide proper antecedent basis for the claimed subject matter in relation to "superconducting" as used in claim 2 and "piezoelectric and magnetostrictive" as used in claims 35 and 36. It is respectfully suggested, however, that the specification does provide proper antecedent basis for these terms. In particular, reference is made to page 26, lines 14-16 of the specification and page 16, line 24, respectively. In the office action, the Examiner has also noted a misnumbering of claims and has suggested a proper renumbering. The applicants concur with the Examiner's renumbering.

Finally, the Examiner has also rejected all the claims as anticipated under 35 U.S.C. §102(b) over the Smith et al. paper. It is assumed that the Examiner is referring

to the Smith et al. paper identified in the information disclosure statement filed in this case and published September 6, 1999. In order to be an anticipating reference under 35 U.S.C §102(b) a printed publication must have been published more than one year prior to the date of filing of the patent application. The present application claims priority under 35 U.S.C. §119 on a prior U.S. provisional application Serial No. 60/190,373 filed March 17, 2000 and therefore enjoys the benefit of this filing date. Since the Smith et al. paper was published less than one year prior to the filing date enjoyed by the present application, it does not qualify as §102(b) prior art. For this reason it is respectfully suggested that the Examiner's rejection is improper and should not stand.

CONCLUSION

It is believed that all matters raised in the December 10, 2002 office action have been addressed herein. In particular, typographical errors in the specification and claims have been amended. Substitute drawings have been provided and other amendments made in response to the Examiner's objections related to form. Finally, a rejection under 35 U.S.C. §102(b) has been addressed. It is believed that the application is now in condition for allowance and timely passage is respectfully requested. Should the Examiner have any matters that remain to be addressed, the favor of a telephone conference with the undersigned is respectfully requested.

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Serial No. 09/811,376

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment, captioned **"Version with markings to show changes made."**

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification:

Please replace the paragraph beginning on page 7, line 14, with the following rewritten paragraph:

--A preferred composite media includes a periodic array of conducting elements that can behave as a continuous medium for electromagnetic scattering when the wavelength is sufficiently longer than both the element dimension and lattice spacing. ~~medium~~ The preferred composite medium has an effective permittivity $\epsilon_{\text{eff}}(\omega)$ and an effective permeability $\mu_{\text{eff}}(\omega)$ which are simultaneously negative over a common band of frequencies.--

Please replace the paragraph beginning on page 8, line 12, with the following rewritten paragraph:

--FIG. 5(b) illustrates a single unit structure for an alternate embodiment of the invention; and--

Please replace the paragraph beginning on page 8, line 14, with the following rewritten paragraph:

--FIG. 6 illustrates a "G" resonator;--

Please add the following new paragraphs beginning on page 8, line 15:

--FIG. 7 illustrates one periodic "swiss roll" resonator structure; and

FIG. 8 illustrates one periodic spiral resonator structure.--

Please replace the paragraph beginning on page 11, line 9, with the following rewritten paragraph:

--Because of the difficulties associated with inherently magnetic media, it is convenient to utilize non-magnetic media to achieve an effective magnetic response. Structures in which local currents are generated that flow so as to produce *solenoidal* currents in response to applied electromagnetic fields, can produce the same response as would occur in magnetic media, but at much higher frequencies. Generally, any element that includes a non-continuous conducting path nearly enclosing a finite area, and further introduces capacitance into the circuit by some means, will have solenoidal currents induced when a time-varying magnetic field is applied parallel to the axis of the circuit. We term such an element a *solenoidal resonator*, as such an element will possess at least one resonance at a frequency ω_{m0} determined by the introduced capacitance and the inductance associated with the current path. Solenoidal currents are responsible for the responding magnetic fields, and thus solenoidal resonators are equivalent to magnetic scatterers. A simple example of a solenoidal resonator is ring of wire, broken at some point so that the two ends come close but do not touch, and in which capacitance has been increased by extending the ends to resemble a parallel plate capacitor. A composite medium composed of solenoidal resonators, spaced closely so that the resonators couple magnetically, exhibits an effective permeability. Such a composite medium was

described in the text by I. S. Schelkunoff and H. T. Friis, *Antennas: Theory and Practice*, Ed. S. Sokolnikoff (John Wiley & Sons, New York, 1952), in which the generic form of the permeability (in the absence of resistive losses) was derived as--

Please replace the paragraph beginning on page 16, line 11, with the following rewritten paragraph:

--In one preferred embodiment, the electric and magnetic units are periodically distributed, although within each unit the effective permittivity or permeability may be anisotropic, resulting in a medium in which the left-handed frequency band occurs only for one or two propagation directions. The spatial distributions of the units may include fractal, pseudorandom, random, or many other types. Either one or both of the negative permeability and negative permittivity media used in the composite medium of the invention may be modulated via external or internal stimulus. Thus, the composite medium may be switched between left-handed and right-handed properties, or between transparent (left-handed) and opaque (non-propagating) over at least one band of frequencies. Such switching is the extreme case, with lesser modulations to change values of permittivity or permeability within the positive and negative range also being useful. Another possibility is the use of a substrate which responds to external or internal stimulus. A substrate that includes a piezoelectric material may serve to modulate the physical size of the substrate by a locally applied electric field. A substrate or element component incorporating magnetostrictive material

may serve also to modulate the physical size of the substrate by an applied magnetic field. Additionally, the medium or a portion thereof may contain other media that have medium electromagnetic parameters that can be modulated. For example, a portion of the medium may be modulated by diverse resonance excitation such as NMR (“Nuclear Magnetic Resonance”), EPR (“Electron Paramagnetic Resonance”), CESR (“Conduction Electron Spin Resonance”), AFR (“Adiabatic Fountain Resonance”), FMR (“Functional Magnetic Resonance”), and paraelectric resonance. Additionally, media used may be photomodulated. The frequency position, bandwidth, and other properties of the left-handed propagation band can then be altered, for example, by an applied field or other stimulus.--

Please replace the paragraph beginning on page 21, line 2, with the following rewritten paragraph:

--Here, ρ is the resistance per unit length of the rings measured around the circumference, ω is the frequency of incident radiation, ℓ is the distance between layers, r , and a , the dimensions indicated in FIG. 2(a), a is the distance in the lattice from one ring to the next in the planar direction, F is the fractional area of the unit cell occupied by the interior of the split ring, Γ is the dissipation factor, and C is the capacitance associated with the gaps between the rings. The expressions for ω_0 and Γ can be found by comparing the terms in

Equation 5. Since the Q-factor of an individual SRR used in the experiments was measured to be greater than 600. Thus, effects due to damping are relatively small.--

Please replace the paragraph beginning on page 22, line 1, with the following rewritten paragraph:

--Using MAFIA (MAFIA is a trademark of Computer Simulation Technologies of America, Inc., Wellesley Hills, MA) Release 4.0, a commercial finite-difference code, dispersion curves were generated for the periodic infinite metallic structure consisting of the split ring resonators of FIG. 1. The dispersion curves are shown in FIGs. 3(a)-3(d). There are two incident polarizations of interest: magnetic field polarized along the split ring axes (H_{\parallel} , FIG. 3(a) inset), and perpendicular to the split ring axes (H_{\perp} , FIG. 3(b) inset). In both cases, the electric field is in the plane of the rings. As shown by the curves in FIGs. (3)a and 3(b), a band gap is found in either case, although the H_{\parallel} gap of FIG. 3(a) can be interpreted as being due to negative $\mu_{\text{eff}}(\omega)$, and the H_{\perp} gap of FIG. 3(b) can be interpreted as being due to a negative $\epsilon_{\text{eff}}(\omega)$. The negative permeability region for the H_{\parallel} modes begins at 4.2 GHz and ends at 4.6 GHz, spanning a band of about 400 MHz. Not evident from the FIG. 3(b), but consistent with the model indicated in Equation 5, $\mu_{\text{eff}}(\omega)$ switches to a large negative value at the lower band edge, decreasing in magnitude (but still negative) for increasing frequency through

the gap. At the upper band edge, $\mu_{\text{eff}}(\omega) = 0$, and a longitudinal mode exists (not shown), identified as the magnetic plasmon mode by Pendry et al. For the dielectric gap shown in FIG. 3(b), the same behavior is observed, but with the roles of $\epsilon_{\text{eff}}(\omega)$ and $\mu_{\text{eff}}(\omega)$ reversed.--

Please replace the paragraph beginning on page 24, line 5, with the following rewritten paragraph:

--where ω is incident frequency, ω_p is plasma frequency, ω_b is greater than ω_0 , and ω_b and ω_0 define endpoints of a typical left handed propagation frequency band. --Equation (6)

shows that the range of the propagation band (k real) extends from ω_0 to $\omega_b = \omega_0 / \sqrt{1 - F}$. $\rightarrow \text{def}$

This was formerly the region of the gap of the SRR structure in the absence of the posts.

The dispersion relation leads to a band with negative group velocity throughout, and a bandwidth that is independent of the plasma frequency for the condition $\omega_p > \omega_b$.--

Please replace the equation beginning on page 24, line 22, with the following rewritten equation:

$$k^2 = \frac{(\omega^2 - \omega_p^2)(\omega^2 - \omega_f^2)}{c^2(\omega^2 - \omega_0^2)} \quad (7)$$

$$k^2 = \frac{(\omega^2 - \omega_p^2)(\omega^2 - \omega_{2f}^2)}{c^2(\omega^2 - \omega_b^2)} \quad (7)$$

Please replace the paragraph beginning on page 25, line 22, with the following rewritten paragraph:

--For the H_{\parallel} polarization, 17 rows of SRRs were utilized in the H direction, (8 elements deep in the propagation direction) oriented as in FIG. 3(a) (inset). FIG. 4 shows the results of transmission experiments on split rings alone (solid curve), and split rings with posts placed uniformly between (dashed curve). The square array of metal posts alone had a cutoff frequency of 12 GHz; the region of negative permittivity below this frequency, where the medium was opaque, attenuated the transmitted power to below the noise floor of the microwave detector (-52 dBm). When the SRR medium was added to the wire array, a pass band occurred, consistent with the propagation region indicated by the simulation (FIG. 3(c)).--

In the Claims:

Please amend claims 2, 12, 15, renumbered claims 23-41 and 43 as follows:

2. (Amended) The ~~composite left handed material according to~~
medium of claim 1 wherein elements forming both the negative permittivity composite
medium and the negative permeability composite medium are superconducting.

12. (Amended) The medium of claim 11, wherein ~~said left handed the~~
medium transmits a selected band of frequencies at one value of modulable permittivity,
and transmits another selected band of frequencies at another value of modulable
permittivity.

15. (Amended) The ~~medim~~ medium of claim of 14, wherein ~~said left~~
~~handed the~~ medium transmits a selected band of frequencies at one value of modulable
permeability, and transmits another selected band of frequencies at another value of
modulable permeability.

23. (Renumbered) (Amended) A left handed composite medium having
a frequency band in which both effective permeability and effective permittivity are
negative simultaneously, the left handed composite medium comprising:

a supporting substrate;

an array of elements each of which contributes with other elements of said array to form define negative permeability composite medium having a negative permeability over a band of frequencies in said frequency band; and

an array of elements arranged, with said negative permittivity composite medium by said substrate, each of said elements contributing with other elements of said array to form define an composite medium having a negative permittivity composite medium, the combination of said negative permeability composite medium and said negative permittivity composite medium forming defining a composite effective medium having a negative permittivity and a negative permeability over at least one common band of frequencies.

24. (Renumbered) (Amended) The left handed medium of claim ~~24~~ 23, wherein said negative permeability composite medium comprises arrays of solenoidal resonator conductive elements.

25. (Renumbered) (Amended) The left handed medium of claim ~~24~~ 23, wherein said negative permeability composite medium comprises arrays of split ring resonator conductive elements.

26. (Renumbered) (Amended) The left handed composite medium of claim ~~26~~ 25, wherein each said split ring conductive element comprises a split rectangular conducting resonator.

27. (Renumbered) (Amended) The left handed medium of claim ~~24~~ 23, wherein said negative permeability composite medium comprises arrays of "G" conductive elements.

28. (Renumbered) (Amended) The left handed medium of claim ~~24~~ 23, wherein said negative permeability composite medium comprises arrays of Swiss roll resonator conductive elements.

29. (Renumbered) (Amended) The left handed medium of claim ~~24~~ 23, wherein said negative permeability composite medium comprises arrays of spiral resonator conductive elements.

30. (Renumbered) (Amended) The left handed medium of claim ~~24~~ 23, wherein each said negative permittivity composite medium comprises a low resistance conducting path arranged adjacent to a corresponding solenoidal resonator conductive element and perpendicular to the axis of the corresponding solenoidal resonator conductive element.

31. (Renumbered) (Amended) The left handed medium of claim 24 23, wherein each said negative permittivity composite medium comprises a conducting wire arranged adjacent to a corresponding solenoidal resonator conductive element and perpendicular to the axis of the corresponding solenoidal resonator conductive element.

32. (Renumbered) (Amended) The left handed medium of claim 24 23, wherein each said negative permittivity composite medium comprises a conducting path ~~formed~~ defined by a confined plasma arranged adjacent to a corresponding solenoidal resonator conductive element and perpendicular to the axis of the corresponding solenoidal resonator conductive element.

33. (Renumbered) (Amended) The left-handed composite medium of claim 24 23, wherein each said negative permittivity composite medium comprises a conducting path ~~formed~~ defined by a confined plasma arranged adjacent to a corresponding solenoidal resonator conductive element.

34. (Renumbered) (Amended) The left handed composite medium of claim 24 23, wherein said substrate comprises a piezoelectric medium.

35. (Renumbered) (Amended) The left handed composite medium of claim 24 23, wherein said substrate comprises magnetostrictive medium.

36. (Renumbered) (Amended) The left handed composite medium of claim ~~24~~ 23, further comprising a scattering defect within the composite left-handed medium.

37. (Renumbered) (Amended) A left handed composite medium having a frequency band in which both effective permeability and effective permittivity are negative simultaneously, the left handed composite medium comprising:

a plurality of adjacent units;

one or more split conductive element resonators disposed in each of said plurality of adjacent units, said split conductive element resonators ~~being formed from~~ defined by two concentric conductive elements of thin metal sheets with a gap between the two concentric conductive elements and a break in continuity of each of said two conductive elements; and

one or more conducting wires disposed in each of said plurality of adjacent units, each wire parallel to a plane of each of said split conductive element resonators disposed in each of said plurality of adjacent units; wherein

said split conductive element resonators and said conducting wires having a common frequency band over which there is simultaneous negative effective permeability and permittivity.

38. (Renumbered) (Amended) The left handed medium of claim ~~38~~37, wherein said concentric conductive elements comprise concentric split rectangular elements.

39. (Renumbered) (Amended) The left handed medium according to claim ~~38~~37, wherein said concentric conductive elements comprise concentric split rings.

40. (Renumbered) (Amended) The left handed medium according to claim ~~38~~37, wherein each of said units not on an outer edge of said medium includes two sections of orthogonal substrate, each of said two sections including one of said concentric conductive elements on a surface thereof, and each having an associated conducting wire.

41. (Renumbered) (Amended) The left handed medium according to claim ~~41~~40, wherein multiple concentric conductive elements are linearly arranged in series on each of said two sections of each of said units not on an outer edge of said medium.

43. (Renumbered) (Amended) The medium of claim ~~43~~42, wherein means are introduced that permit the adiabatic absorption along any direction of propagation within said medium.